Mortality Among Very Low-Birthweight Infants in Hospitals Serving Minority Populations

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Objective. We investigated whether the proportion of Black very low-birthweight (VLBW) infants treated by hospitals is associated with neonatal mortality for Black and White VLBW infants.

Methods. We analyzed medical records linked to secondary data sources for 74 050 Black and White VLBW infants (501 g to 1500 g) treated by 332 hospitals participating in the Vermont Oxford Network from 1995 to 2000. Hospitals where more than 35% of VLBW infants treated were Black were defined as "minority-serving."

Results. Compared with hospitals where less than 15% of the VLBW infants were Black, minority-serving hospitals had significantly higher risk-adjusted neonatal mortality rates (White infants: odds ratio [OR] = 1.30, 95% confidence interval [CI] = 1.09, 1.56; Black infants: OR = 1.29, 95% CI = 1.01, 1.64; Pooled: OR = 1.28, 95% CI = 1.10, 1.50). Higher neonatal mortality in minority-serving hospitals was not explained by either hospital or treatment variables.

Conclusions. Minority-serving hospitals may provide lower quality of care to VLBW infants compared with other hospitals. Because VLBW Black infants are disproportionately treated by minority-serving hospitals, higher neonatal mortality rates at these hospitals may contribute to racial disparities in infant mortality in the United States. (*Am J Public Health.* 2005;95:2206–2212. doi:10.2105/AJPH.2004.046730)

Neonatal mortality in the United States fell from 28.8 deaths per 1000 live births in 1940 to 4.6 deaths per 1000 live births in 2000.[1] Yet despite this tremendous gain in infant survival, racial and ethnic disparities in neonatal mortality have persisted or even increased over time. In Black and White infants, the disparity in neonatal mortality, defined as mortality in the first 28 days of life, has actually increased in recent years from twice as high for Black infants compared with White infants in 1980, to two-and-one-half times as high for Black infants in 2000.[1,2] This and other disparities in mortality are a major health policy concern and led the president of the United States to identify infant mortality as 1 of 6 areas to be targeted to reduce racial disparities in health in the United States.

Previous studies have identified several hospital characteristics associated with health outcomes for infants. One study found that infants born in hospitals with large-volume tertiary neonatal intensive care units (NICUs) had the most favorable mortality rates.[3] In another study, low-birthweight infants (<2000 grams) born in hospitals without NICUs or with small or intermediate NICUs had significantly higher mortality compared with infants born in hospitals with regional NICUs.[4] In a recent study, very low-birthweight (VLBW) infants born in hospitals with higher volume NICUs had lower mortality than VLBW infants born in hospitals with lower volume NICUs.[5] Finally, previous studies have found that lower staff-to-infant ratios and higher staff workload levels are associated with higher mortality rates among very low-birthweight infants.[3,6,7]

Studies of adult patients have also identified hospital characteristics associated with health outcomes. These include whether a hospital is located in an urban setting, a hospital's profit status, whether a hospital is a teaching institution, the number of patients treated, and the institution's financial status.[8–13] Adult studies have also found that health outcomes vary by the patient population a hospital serves. For example, 1 study of adult patients discharged from 51 randomly selected hospitals in New York found that hospitals primarily serving minority patients had significantly more negligent adverse events (defined as injuries caused by medical treatment) than non–minority-serving hospitals.[14] Another study found that hospitalized Black Medicare patients were more likely than their White counterparts to receive lower quality of care.[15] No similar studies have examined the association between the racial and ethnic makeup of the infants treated by hospitals and their health outcomes.

To help address this gap, we investigated whether the proportion of minority infants treated by hospitals is associated with neonatal mortality in a high-risk population of VLBW infants. In the United States, mortality among VLBW infants accounts for more than half of all infant deaths.[1] To the extent that we found mortality differences by the proportion of minority infants treated by hospitals, we investigated whether these differences were explained by other hospital characteristics such as patient volume, level of care at the hospital, or differences in the use of effective treatments.

METHODS

Setting

The Vermont Oxford Network (VON) is a voluntary collaborative network of hospitals with NICUs in 49 states and 22 foreign countries (http://www.vtoxford.org). All US hospitals participating in the VON during the years 1995 to 2000 participated in this study with the exception of 1 that was excluded because of lack of follow-up data for infants transferring to other hospitals. Of the 332 hospitals that participated, 108 had data for all years and the remainder had data for 1 to 5 years. Hospitals with less than a full panel of data mainly comprised those that joined the network after 1995.

The study sample includes all Black and White infants between 501 g and 1500 g born in VON hospitals between 1995 and 2000 (n=74 050). Infants that were not Black or White were excluded because of their small numbers. Infants who died in the delivery room or other locations in the hospital were included in the study even if they were not admitted to the NICU. Infants treated by VON hospitals were tracked until they were either discharged home or they died. Infants treated by VON hospitals but born at non-VON hospitals were excluded from the study sample because hospital of birth is an important predictor of infant survival.[3,4] Infants with birthweights 500 g and less were excluded from the study for consistency with prior studies.

Data Sources

The VON database was our primary source of data. The VON database contains detailed, uniformly collected clinical and treatment data abstracted from the medical charts of all VLBW infants. The available data for each infant include neonatal mortality, gestational age, birthweight, 1-minute Apgar score, and sex, as well as indicators of multiple birth, congenital malformations, vaginal delivery, any prenatal care, and treatment with antenatal steroids or surfactants. The VON uses various quality assurance procedures and conducts data quality audits to maintain accurate and complete data for all participating hospitals.[16]

The VON database also includes maternal race, which was used to assign infants to a racial category, and the mother's zip code of residence, which was used to assign mothers an income and education level on the basis of 1990 US Census data. The use of census-based imputation methods in estimating infant mortality has been shown to be valid.[17] With the exception of birthweight and gender (which were never missing), missing values for all variables were imputed. Overall, less than 2% of infants had missing data for any given variable.

Hospital characteristics were determined with the VON annual institutional survey, the American Hospital Association (AHA) annual survey, and the area resource file. The VON annual institutional survey was used to determine the level of care provided by each hospital's NICU. The VON assigns each NICU to 1 of 3 levels: Level A (restriction on ventilation, minor surgery only), Level B (major surgery), and Level C (cardiac surgery). The AHA annual survey and area resource file were used to determine hospital ownership status, teaching status (as measured by membership in the Council of Teaching Hospitals), location in a major urban area with population over 1 million, regional location within the United States, percent of patient days paid for by Medicaid, and total expenditures per hospital admission. Expenditures were adjusted to year 2000 dollars using the medical component of the consumer price index to account for inflation. Expenditures also were adjusted for cross-sectional differences in hospital input prices across geographic areas using the Medicare wage index and the capital cost index.

Statistical Methods

Multivariate logistic regression models were used to evaluate the relationship between neonatal mortality and hospital characteristics among Black and White VLBW infants (501 g–1500 g). The unit of observation in this study was an individual infant at the hospital where the birth occurred.

Outcome Variable

The outcome measure in this study was neonatal mortality, defined as mortality prior to discharge home during the first 28 days after birth.

Main Explanatory Variable

Definition of minority-serving status. On the basis of the proportion of VLBW infants they treated over the 6-year period of the study that were Black, hospitals were assigned to 1 of 3 categories (i.e., <15% Black, 15% to 35% Black, and >35% Black). These categories were chosen because they divided our hospitals (but not the babies) into 3 groups of approximately equal size. Of the 332 hospitals in the study, 113 (34%) were in the less-than-15% category, 121 (36%) were in 15%-to-35% category, and 98 (30%) were in the more-than-35% category. In the remainder of this paper, we refer to hospitals that treated more than 35% Black infants as "minority-serving hospitals."

The percentage of Black infants treated by a hospital was derived by dividing the number of Black infants treated between 1995 and 2000 by the number of Black and White infants treated over the same time period. In cases where hospitals did not belong to the Vermont Oxford Network for the entire study period, we used available years of data.

Other Explanatory Variables

Risk-adjustment model. To control for differences in infant severity of illness across hospitals, we used the VON risk-adjustment model.[18] The VON risk-adjustment model includes gestational age in weeks (and its square), small for gestational age, 1-minute Apgar score (ranging from 0–10, with higher values indicating better health), and indicators for Black race, male sex, multiple births, major birth defect, vaginal delivery (vs cesarean section), and any prenatal care. Small for gestational age, defined by a birthweight less than the 10th percentile for gestational age based on race and sex, was derived from the 1993 US Center for Health Statistics Natality data set by the VON.[19] We augmented the VON risk-adjustment model with maternal income (dollars) and education (years).

Hospital characteristics. To assess whether hospital characteristics could account for differences in neonatal mortality among hospitals by minority-serving status, we examined hospital region (Northeast, Midwest, South, West), hospital location in a major urban area (urban or rural), hospital NICU volume (<40 infants per year, ≥40 infants per year), hospital NICU level of care (levels A and B or level C), hospital ownership (not-for-profit, for-profit, or public), hospital teaching status (teaching or nonteaching), the percentage of hospital admissions covered by Medicaid, and hospital expenses per admission. Total expenditures per admission were included as an indicator of resource use per admission. In addition, we examined the mean hospital level of maternal education and the median hospital level of maternal income to capture socioeconomic differences among the hospital patient population not captured by race.

Process of care. To assess whether process-of-care differences could account for differences

TABLE 1—Infant Characteristics by Racial Group

	All (N = 74 050)	White (n = 49 132)	Black (n = 24 918)
Neonatal infant mortality	11	11	11
Birthweight, g	1048.46	1064.45	1016.93*
Gestational age, weeks	28.47	28.63	28.15*
One-minute Apgar score	5.37	5.46	5.21*
Male sex, %	51	51	50*
Small for gestational age, %	21	22	20*
Multiple birth, %	29	34	19*
Congenital malformation, %	4	5	3*
Vaginal delivery, %	38	34	45*
Maternal Black race, %	34	0	100*
Had prenatal care, %	96	98	92*
Mean maternal education, years	12.41	12.57	12.10*
Mean maternal income, $1000s	36.01	38.04	32.02*
Year, %			
1995 (n = 6663)	9	9	8*
1996 (n = 8989)	12	12	12*
1997 (n = 12 147)	16	17	16*
1998 (n = 14 271)	19	19	19
1999 (n = 15 416)	21	20	22*
2000 (n = 16 564)	22	22	23*

*$P < .01$ for test of null hypothesis that the difference in the rates for Blacks and Whites is 0.

in neonatal mortality among hospitals by minority-serving status, we examined 2 variables indicating treatment with surfactants and antenatal steroids. Both surfactants and antenatal steroids have been found to be highly effective treatments in VLBW infants.[20–22]

Estimation Procedures

For this study, we used logistic regression models with neonatal mortality as the dependent variable.[23] All analyses were conducted using STATA statistical software (Stata Corp, College Station, Tex; 2001). We used STATA's *cluster* option to obtain variance estimates adjusted for intraclass correlation among observations by hospital.[24,25] For all analyses, a P value of .05 or less was considered statistically significant.

RESULTS

Infant Characteristics

The infant mortality rate among all infants (before risk adjustment) was 11% and did not differ between White and Black infants (Table 1). Black infants accounted for 34% of our sample, and their characteristics at birth differed systematically from those of White infants. Black infants weighed less and were born at earlier gestational age with lower Apgar scores, all factors associated with worse infant outcomes. On the other hand, White infants were more likely to be small for gestational age, born with congenital anomalies, or part of a multiple birth. Black mothers were less likely to receive prenatal care and lived in zip codes with lower income and education than White mothers. Finally, Black infants received treatment with antenatal steroids and surfactants less frequently.

Hospital and NICU Characteristics

The characteristics of hospitals where White and Black infants were born differed systematically (Table 2). Black infants were disproportionately treated by minority-serving hospitals. Eight percent of Black infants were treated by hospitals with the smallest percentage of Black infants (where < 15% of infants were Black) whereas 57% were treated by minority-serving hospitals. By contrast, 39% of White infants were treated by hospitals with the smallest proportion of Black infants whereas 18% were treated by minority-serving hospitals.

In terms of other hospital characteristics that may be associated with quality of care, the difference between White and Black infants was less consistent. On the one hand, relative to White infants, Black infants were more likely to be born in urban and teaching hospitals, characteristics often associated with high quality of care. On the other hand, Black infants were less likely to be born in a hospital with a level-C NICU, and more likely to be born in hospitals that were government-owned, served a high percentage of Medicaid patients, had lower expenses per admission, and were located in the South.

Impact of Minority-Serving Status on Neonatal Mortality

Table 3 shows the results of multivariate logistic regression models estimated separately for Black and White infants. Effects (given as odds ratios [ORs]) and 95% confidence intervals (CIs) of infant-level variables are given at the bottom of the table and hospital-level variables indicating the minority-serving status of the hospital are given at the top of the table. Year indicators were also included but were not statistically significant and their coefficients are not reported.

The infant-level variables have coefficients that are similar for White and Black infants, and resemble those in previous studies.[18,26] Younger gestational age has increasingly large impacts on mortality. Every additional point on the Apgar score reduces mortality by approximately 25%, and being small for gestational age more than doubles the risk of mortality. Infants with major birth defects have an odds ratio of well over 10. Controlling for all of the other risk factors observed at birth, prenatal care, and income and education in the mother's zip code of residence are not significantly related to mortality. Nevertheless, we retained these covariates in subsequent analyses to be consistent with previous studies.[11,15]

What was the effect of a hospital's minority-serving status on neonatal mortality (Table 3)? For both Black and White infants,

TABLE 2—Hospital Characteristics and Processes of Care by Racial Group

	All (n = 74 050), %	White (n = 49 132), %	Black (n = 24 918), %
Hospital Characteristics			
Minority-serving status			
< 15% Black infants	31	39	8%*
15%–35% Black infants	36	43	35*
> 35% Black infants	33	18	57*
Urban hospital	53	48	64*
Region			
Northeast	19	19	20*
Midwest	27	29	23*
South	37	32	48*
West	16	20	10*
Volume < 40 admits per year	8	8	8
Level C (highest level of care)	28	30	24*
Hospital ownership			
Government	11	9	14*
Not-for-profit	83	84	80*
For-profit	7	7	6*
Member, Council of Teaching Hospitals	48	46	52*
Medicaid admissions	16	15	19*
Expense per admission, $1000s	11.7	11.8	11.4*
Processes of Care			
Treatment with antenatal steroids	74	77	69*
Treatment with surfactants	60	61	58*

*$P < .01$ for test of null hypothesis that the difference in the rates for Blacks and Whites is 0.

neonatal mortality was higher in minority-serving hospitals relative to hospitals where less than 15% of the infants were Black (Whites: OR = 1.30; 95% CI = 1.09, 1.56; $P = .004$; Blacks: OR = 1.29; 95% CI = 1.01, 1.64; $P = .040$). Odds ratios for hospitals treating intermediate percentages of Black infants (15%–35%) were about half as large (White: OR = 1.10; Black: OR = 1.16) but were not statistically significant. Thus, there was a consistent and significant relationship between the minority-serving status of a hospital and neonatal mortality, and this relationship held for both Black and White infants.

In secondary analyses, we tested the significance of interactions between race and each of the model covariates including hospital minority-serving status in a pooled sample of Black and White infants. Because none of these interaction terms were significant, we conclude that the effect of each model covariate, including the effects of the covariates for minority-serving hospitals, was the same for Black and White infants. We therefore pooled data for Black and White infants in subsequent analyses without risk of masking differential effects.

Next we investigated whether the higher mortality in minority-serving hospitals could be explained by other hospital characteristics. Table 4 presents the results of 3 multivariate models of neonatal mortality using pooled data for Black and White infants. Model 1 replicates the model from Table 3, but is estimated using the pooled sample of Black and White infants. In Model 2, we controlled for additional hospital-level covariates that are commonly associated with patient outcomes. In Model 3, we also controlled for treatment with surfactants or antenatal steroids, 2 treatments known to be effective in reducing mortality and whose use may have differed in minority-serving hospitals. The purpose of Models 2 and 3 was to investigate whether any NICU/hospital variables or treatment variables moderated the effects of minority-serving status on neonatal mortality.

The results of Model 1 show that after risk adjustment, infants treated by minority-serving hospitals had significantly greater odds of mortality than infants treated by hospitals where less than 15% of the infants were Black (OR = 1.28; 95% CI = 1.10, 1.50). We found nearly identical results in Model 2 (OR = 1.25; 95% CI = 1.04, 1.51), and Model 3 (OR = 1.26; 95% CI = 1.04, 1.52). Together, these findings show that neonatal mortality is higher among infants treated by minority-serving hospitals than infants treated by other hospitals, even after risk adjustment and controlling for a range of other NICU/hospital variables and treatment variables. Moreover, these findings show that the effect of being treated by a minority-serving hospital is large in magnitude relative to the effect of other hospital characteristics. In fact, only low volume (< 40 infants) is associated with an effect of similar magnitude.

In secondary analyses, we tested the statistical significance of interaction terms between race and minority-serving status in each of the 3 pooled data models. Our results showed that these interaction terms were not significant, suggesting that Black and White infants were at similarly higher odds of mortality when treated by minority-serving hospitals compared with other hospitals. Interaction terms between race and the other hospital and NICU characteristics and the process-of-care measures were also not statistically significant.

Differences Among Infants and Hospitals by Minority-Serving Status

As Table 5 shows, the expected mortality was identical among the populations of infants treated in hospitals where less than 15% of the VLBW infants were Black, 15% to 35% were Black, and more than 35% were Black. Thus, the 3 categories of hospitals in this study appear to be treating similar populations of infants with respect to their severity of illness. With respect to hospital characteristics, infants born in minority-serving hospitals were more likely to be treated by Southern hospitals, urban

TABLE 3—Logistic Regressions on Neonatal Mortality by Racial Group

	White Odds Ratio (95% CI)	Black Odds Ratio (95% CI)
Minority-serving status		
<15% Black infants	1.00	1.00
15%–35% Black infants	1.10 (0.97, 1.27)	1.16 (0.91, 1.47)
>35% Black infants	1.30 (1.09, 1.56)**	1.29 (1.01, 1.64)*
Gestational age	0.04 (0.04, 0.05)**	0.04 (0.03, 0.05)**
Gestational age squared	1.05 (1.05, 1.05)**	1.05 (1.05, 1.06)**
One-minute Apgar score	0.73 (0.71, 0.74)**	0.75 (0.72, 0.77)**
Small for gestational age	2.44 (2.14, 2.77)**	2.28 (1.93, 2.69)**
Multiple birth	1.32 (1.20, 1.45)**	1.22 (1.07, 1.39)**
Congenital malformation	16.50 (14.46, 18.82)**	14.74 (11.48, 18.9)**
Vaginal delivery	1.36 (1.25, 1.49)**	1.36 (1.21, 1.52)**
Prenatal care	0.94 (0.77, 1.15)	0.85 (0.72, 1.01)
Maternal income	1.00 (1.00, 1.01)	1.00 (0.99, 1.01)
Maternal education	1.01 (0.95, 1.06)	0.99 (0.93, 1.07)
Male	1.25 (1.17, 1.34)**	1.28 (1.15, 1.43)**
Model Pseudo R-square	0.39	0.36

Note. CI = confidence interval. Models include dummy variables for years 1995 to 2000.
*$P < .05$ for test of null hypothesis that the odds ratio is 1.00.
**$P < .01$ for test of null hypothesis that the odds ratio is 1.00.

hospitals, and government-owned hospitals. Infants born in minority-serving hospitals were also less likely to have received antenatal steroids. However, it is important to keep in mind when interpreting these results that although these variables vary among hospitals according to minority-serving status, they did not account for mortality differences in the multivariate regression models we estimated.

DISCUSSION

This study suggests that minority-serving hospitals may be providing lower quality of care to VLBW infants than other hospitals. Our results show that VLBW infants treated by minority-serving hospitals are at significantly higher odds of neonatal mortality than VLBW infants treated by hospitals where less than 15% of the VLBW infants treated were Black (OR=1.28; 95% CI= 1.10, 1.50). Furthermore, these results were not explained by other hospital characteristics, including location in a major urban setting, teaching status, or the percentage of hospital admissions covered by Medicaid; or by NICU characteristics including patient volume or NICU level of care; or by process-of-care variables such as treatment with antenatal steroids or surfactants.

This study is consistent with and adds to the published literature on hospital characteristics associated with infant mortality. Previous studies have found that higher patient volume, higher NICU level of care, higher nurse-to-patient ratios, and lower staff workload are all associated with lower neonatal mortality.[3–7] This study confirms that NICU volume and NICU level of care are independently associated with neonatal mortality. This study adds to the published literature in that it finds that minority-serving status is associated with neonatal mortality, independent of any of the NICU/hospital variables or treatment variables we included in this study.

Higher neonatal mortality at minority-serving hospitals in addition to the fact that Black VLBW infants are much more likely to be treated by minority-serving hospitals (57% for Blacks vs 18% for Whites) suggests that the racial disparity in neonatal mortality could be reduced by improving mortality outcomes for VLBW infants treated by minority-serving hospitals. On the basis of our estimates, if neonatal mortality in minority-serving hospitals were reduced to the level we observed in hospitals where less than 15% of the VLBW infants are Black, overall mortality would be reduced by approximately 10% for White infants and by approximately 22% for Black infants.

In contrast to previous studies in adults,[15] we did not find evidence of differential quality of care by race among VLBW infants. Specifically, we found that the probabilities of neonatal mortality were similarly elevated for Black (OR=1.29; 95% CI=1.01, 1.64) and White (OR=1.30; 95% CI=1.09, 1.56) VLBW infants treated by minority-serving hospitals compared with hospitals treating less than 15% VLBW Black infants. These results support a hypothesis that among VLBW infants, system-level characteristics are important in understanding racial disparities in care, a hypothesis also highlighted in the recent Institute of Medicine report on unequal treatment.[27]

Hospital characteristics other than those we were able to examine in this study may account for higher neonatal mortality in minority-serving hospitals. Previous studies have found that infant-to-nurse ratios and staff workload are associated with mortality in VLBW infants.[6,7] In studies of hospitalized adults, the percentage of board-certified specialists and foreign medical graduates and nurse-to-patient ratios are associated with mortality.[28,29] Previous studies have also found an association between the financial status of hospitals and patient mortality.[13] Future research should investigate whether financial status, staffing patterns, or other hospital characteristics explain the difference in neonatal mortality between minority-serving hospitals and other hospitals.

Unmeasured severity of illness may account for higher infant mortality in minority-serving hospitals. Although this is a plausible explanation, it is unlikely for several reasons. First, our risk-adjustment model compares quite favorably to the Score for Neonatal Acute Physiology, a state-of-the-science risk-adjustment model.[18,30–32] Second, the expected mortality rate for Black and White VLBW infants treated by hospitals where less than 15% of the treated infants were Black, 15% to 35% were Black, and greater

TABLE 4—Results of Pooled Logistic Regressions on Neonatal Infant Mortality

	Model 1 Odds Ratio (95% CI)	Model 2 Odds Ratio (95% CI)	Model 3 Odds Ratio (95% CI)
Minority-serving status			
<15% Black infants	1.00	1.00	1.00
15%–35% Black infants	1.12 (0.98, 1.27)	1.11 (0.98, 1.27)	1.11 (0.98, 1.27
>35% Black infants	1.28 (1.10, 1.50)**	1.25 (1.04, 1.51)*	1.26 (1.04, 1.52*)
Urban setting		1.10 (0.98, 1.23)	1.10 (0.97, 1.24)
Regional location			
Northeast		1.00	1.00
Midwest		1.09 (0.90, 1.31)	1.09 (0.89, 1.32)
South		1.05 (0.90, 1.23)	1.05 (0.90, 1.24)
West		1.21 (1.00, 1.45)*	1.19 (0.98, 1.44)
NICU volume			
≥40 Infants		1.00	1.00
<40 Infants		1.29 (1.12, 1.49)**	1.27 (1.10, 1.46)**
Level of care			
Levels A and B		1.00	1.00
Level C		0.86 (0.76, 0.98)*	0.86 (0.76, 0.98)*
Hospital ownership			
Private not-for-profit		1.00	1.00
Private for-profit		0.83 (0.67, 1.02)	0.79 (0.65, 0.95)*
Government		1.07 (0.91, 1.26)	1.07 (0.90, 1.26)
Teaching hospital		1.02 (0.91, 1.15)	1.03 (0.91, 1.17)
Percent Medicaid admissions		1.04 (0.55, 1.97)	0.96 (0.51, 1.84)
Expenses per admission, $1000s		1.01 (0.99, 1.02)	1.01 (0.99, 1.03)
Average education (hospital level)		0.91 (0.80, 1.03)	0.95 (0.83, 1.09)
Average income (hospital level)		1.00 (0.99, 1.02)	1.00 (0.98, 1.01)
Treatment with antenatal steroids (infant level)		0.54 (0.50, 0.58)**	
Treatment with surfactants (infant level)		0.56 (0.50, 0.62)**	
Model Pseudo R-square	0.38	0.38	0.39

Note. CI = confidence interval; NICU = neonatal intensive care unit. All models include gestational age, gestational age squared, 1-minute Apgar, small for gestational age, multiple births, congenital malformations, vaginal delivery, prenatal care, maternal income, maternal education, infant sex, maternal race, and dummy variables for years 1995 to 2000.
*P < .05 for test of null hypothesis that the odds ratio is 1.00.
**P < .01 for test of null hypothesis that the odds ratio is 1.00.

than 35% were Black was nearly identical. This suggests that the severity of illness of infants treated at the 3 types of hospitals we studied was nearly identical, risk adjustment notwithstanding.

This study has potential limitations. First, the sample of hospitals participating in the VON is similar but not identical to the universe of US hospitals with NICU beds. A comparison of VON hospitals with the universe of hospitals in the US with any NICU beds showed that VON hospitals were more likely to be private nonprofit (78% vs 72%) and less likely to be for-profit hospitals (7% vs 10%) and public hospitals (13% vs 18%). They were also more likely to be teaching hospitals (14% vs 5%) and children's hospitals (14% vs 5%) and to have higher average numbers of total and NICU beds (21 NICU beds vs 17 NICU beds).

Second, the sample of VLBW infants included in the VON is similar but not identical to the universe of VLBW infants treated in the United States. Compared with the universe of VLBW Black infants in the United States, VLBW Black infants in the VON were smaller (1016.93 g vs 1009.82 g), but were similar in terms of gestational age (28.14 weeks vs 28.14 weeks). Compared with the universe of White VLBW infants, White infants in the VON were larger (1057.39 g vs 1064.45 g), but also similar in terms gestational age (28.83 weeks vs 28.63 weeks).

In summary, this study points to the importance of hospital characteristics in understanding racial disparities in infant mortality. After careful risk adjustment, we found that VLBW infants treated by minority-serving hospitals had higher neonatal mortality than VLBW infants treated by other hospitals. Because VLBW Black infants are disproportionately treated by minority-serving hospitals, higher neonatal mortality in minority-serving hospitals may be contributing to racial disparities in infant mortality overall. More research is needed to understand the role of physician and nurse staffing patterns and other hospital organizational factors underlying the main finding of this study. Interventions to improve quality of care and reduce neonatal mortality at minority-serving hospitals may result in reduced racial disparities in infant mortality in the United States. ■

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TABLE 5—Selected Infant Characteristics, Hospital Characteristics, and Processes of Care by Hospital Minority-Serving Status

	Percentage of Black Infants Treated by a Hospital		
	<15	15-35	>35
Overall expected neonatal mortality	11	11	11
Hospital Characteristics			
Urban hospital	43	54	63*
Region			
South	13	37**	60**
West	40	11**	1**
Level C (highest level of care)	42	25*	19**
Hospital ownership			
Government	8	6	20*
For-profit	11	4	6
Medicaid admissions	15	14	20*
Processes of Care			
Treatment with antenatal steroids	77	76	71**
Treatment with surfactants	61	59	60

*P < .05 for test comparing category mean to mean for hospitals that treated < 15% Black infants.
**P < .01 for test comparing category mean to mean for hospitals that treated < 15% Black infants.

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